

DEVELOPMENT AND EVALUATION OF NUTRILADDU FOR COMBATING ANAEMIA AND UNDERWEIGHT

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ABSTRACT

This study conducted in 2023 aimed to develop iron and calorie rich nutritious recipe from inexpensive and indigenous ingredients, to be used as food supplement to prevent anaemia and enhance weight among undernourished and anaemic individuals. Iron rich ingredients such as Bajra, Amaranth seeds, Rice flakes, Black gram, Roasted Bengal gram, Groundnuts Sesame, Garden cress seeds, Cauliflower leaves powder, Amla powder were used to formulate nutrimix at three different proportions as variations V1, V2 and V3 along with Jaggery and Ghee to prepare Nutriladdu. Organoleptic evaluation was done by a panel of 30 semi trained members using 9 - point hedonic scale to assess the sensory attributes of the prepared laddus. Nutritional analysis was conducted to estimate energy, protein, carbohydrate, fat, iron, and beta carotene, along with a microbiological analysis to assess shelf life. The results showed that the laddu prepared with nutrimix V1 was selected as food supplement, due to its highest average sensory score as determined by one-way ANOVA compared to the other compositions. The nutritional analysis indicated that the Nutriladdu (V1) per 100g contains 412 kcal, 12.93g of protein, 47.78g of carbohydrates, 18.36g of fat, 7.324mg of iron, 65.93mg of calcium, and 30.07µg (8.42 IU) of vitamin A. Shelf-life analysis showed acceptability for up to 15 days of storage at room temperature. The findings indicate a potential enhancement of nutrient content in recipes by integrating cauliflower leaves, garden cress seeds, and amla at a 10 percent level, without adversely affecting sensory quality. Fortifying the menu with nutriladdu as a snack would serve as an effective food-based strategy to prevent or ameliorate anemia and promote weight gain among undernourished individuals.

Keywords: Iron Deficiency Anaemia (IDA), Nutrient analysis, Nutriladdu, Nutrimix, Organoleptic evaluation, Underweight

INTRODUCTION

Despite being one of the first countries in the world to initiate the National Nutritional Anemia Prophylaxis Programme in 1970, Iron Deficiency Anaemia (IDA) is still an unresolved nutritional problem in India. According to the National Family Health Survey (NFHS-5, 2019-

21), the prevalence of anemia among Indian women aged 15-49 years is still high (>50%). Among children aged 6-59 months, 67.1% were affected, with 52 percent of pregnant women were reported to be anaemic. Despite the complexity of anaemia's causes, it is believed that iron deficiency accounts for roughly 50%

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of instances. Underweight remains a significant public health concern, affecting various demographic groups, particularly children and women. According to a pooled analysis of 2146 population-based studies involving 128.9 million children, adolescents, and adults worldwide (Lancet, 2017), approximately one-third of male peers and one fifth of girls aged 5-19 are underweight, making South Asia as the region with the highest occurrence of moderate to severe underweight. South Asia, including India, had exhibited the lowest BMIs among both male and female adolescents. The National Family Health Survey-5 (NFHS 2019-2021) reported that 24% of adolescent girls aged 15-19 years were underweight (BMI < 18.5 kg/m²) with high rates in rural and tribal populations. Malnutrition during adolescence profoundly impacts the developmental processes. Underweight among adolescent girls is nutritional issues perpetuating inter-generational impacts. Anaemia is more common in adolescents in developing countries due to their rapid growth, development, menstruation, plant diets, and limited consumption of animal-based foods that provide bioavailable heme iron (Petry *et al.*, 2016). Due to the growth spurt and menstrual loss, teenage girls have higher iron needs. If their diet is undiversified and does not include foods high in iron in their daily meals, they may be more susceptible to iron deficiency anaemia (IDA), chronic nutritional deficiencies, and undernutrition. Various approaches yield positive outcomes in tackling anaemia such as ensuring dietary variety, incorporating iron-rich foods into daily meals providing iron tablets supplements, fortifying foods with iron and educating the community on Nutrition. (Shikha and Shalini, 2021).

Strategy to resolve anaemia involves enhancing diet to increase iron consumption by choosing foods rich in iron including meat, fish, legumes and green leafy vegetables. This

approach emphasizes iron bioavailability to optimize its absorption through incorporating significant quantities of iron absorption enhancers in meals like vitamin C and meat while minimizing the ingestion of iron inhibitors such as phytates, polyphenols and calcium. Additionally, it involves the fortification of staple foods, including wheat, maize, and rice, alongside the enhancement of knowledge through nutrition education and counselling.

Eating patterns have changed and snacking has become more common. As having snacks in between meals contribute to nutrient intake, help to meet the nutritional recommendations, nutritional quality of the snack needs to be focused. Laddu a traditional Indian sweet snack, is typically made from multiple ingredients. Its widespread consumption across diverse socioeconomic strata, considered as a potential vehicle for nutritional interventions particularly addressing iron deficiency anaemia. Development of nutrient dense iron rich laddu from multiple ingredients addresses a significant dietary need for anaemia prevention and promote weight gain among individuals who have the habit of consuming snacks in between the meal. This study was carried out with the objective to develop a nutritious snack-laddu using iron rich ingredients from different food groups, assessing the sensory attributes and nutrient composition of the developed laddu.

MATERIAL AND METHODS

Product formulation

Procurement and Processing of Ingredients

The formulation used for the development of Iron rich snack was based on the ICMR recommendations of the basic five food groups. Thus, cost effective, convenient and seasonally available iron rich sources were chosen. Foods from various groups were

chosen based on their nutritive value given in Food Composition Table (Longvah *et al.*, 2017). Accordingly, Rice Flakes, Bajra from cereal and nutri-cereals group, Amaranth seeds from pseudo-cereals, dehusked Black gram, roasted Bengal gram from pulse group, Groundnut, Sesame and Garden cress seeds (halim) from oil seeds group and cauliflower leaf powder from leafy vegetable group and Amla powder from special food or fruit group were selected for nutrimix flour. The ingredients Rice flakes, Pearl millet, Amaranth seeds, Black gram, Roasted Bengal gram, Groundnut, and Sesame were purchased from the local market of Puducherry and were cleaned thoroughly and subjected to suitable processing methods - dry roasting and made into powder/flour slightly coarse in consistency. Dark green Cauliflower leaves were procured from the market, where the daily market has wholesale and retail sale of cauliflower, trimming the leaves aside and leaving it as

waste or given as feed for cattle. The leaves were chosen properly and pale or yellow coloured were not chosen. The leaves were sorted; stalks were removed, washed and dried in an hot air oven and the dried leaves were made into powder. Amla powder, Roasted Bengal gram, roasted peanuts, ghee and jaggery were procured from the market. As per the composition decided, dry roasted the bajra, rice flakes, dehusked black gram, sesame seeds, amaranth seeds and halim seeds on a heavy bottom pan on low heat till golden brown. Once cooled was transferred into powerful blender and was fine powdered. Thus, powdered form of all selected ingredients was made ready for making nutrimix of different proportions.

Formulation of the mix and product

The powder made from the ingredients were mixed in three different compositions each consisting of 100gm of mix. To the

Table 1. The proportion of ingredients used to prepare the Nutriladdu

Ingredients for Nutrimix (Laddu)	Nutriladdu Composition (V1) (g)	Nutriladdu Composition (V2) (g)	Nutriladdu Composition (V3) (g)
Bajra	15	10	5
Amaranth seeds	10	10	5
Rice flakes	15	10	5
Black gram	15	10	5
Roasted Bengal gram	15	10	5
Groundnuts	5	10	15
Sesame	5	10	15
Garden cress seed	10	10	15
Cauliflower leaves powder	5	10	15
Amla powder	5	10	15
Total	100	100	100
Jaggery	30	30	30
Ghee	15	15	15
Total	145	145	145

formulated flour mix, powdered palm jaggery(30gm) was added and by using melted ghee (15gm) the laddu was prepared. Thus, three different variations of laddu were made (Table 1) and accordingly named as V1, V2 and V3.

Sensory evaluation of the Nutriladdu

The sensory evaluation aims to determine the final selected product from three formulations made. Organoleptic evaluation was done using a panel of 30 members which included trained, semi trained and untrained panelists (school girls, post graduate students, research scholars, and staff members and homemakers). The 9-point hedonic scale is a widely used method in organoleptic evaluation to assess and quantify individuals' subjective responses to a product's overall liking or preference. It allows consumers to express their feelings toward a particular item, often a food product, on a scale ranging from 1 to 9. Each point on the scale represents a specific level of liking or disliking, and the scale is typically anchored with verbal descriptors to guide the participants in their evaluation. Minimum score '1' is intensely disliked, and there may be a strong aversion to its organoleptic characteristics. Maximum score of '9' is liked intensely, and there is a strong preference for its organoleptic attributes. This score represents the highest level of liking. Sensory aspects such as appearance, colour, taste, flavour, texture and overall acceptability was evaluated for all the three laddu made with V1, V2 and V3 nutrimix respectively by the panelists using 9 – point hedonic scale. The overall rating was obtained by averaging the scores given by the panelists. The laddu with the highest overall acceptability score was selected for further analysis.

Nutritional analysis of the selected laddu

The samples, designated for supplementation, underwent macronutrient

and micronutrient testing at the Food Quality Testing Laboratory.

Chemical analysis of the selected laddu

Physicochemical analysis of the developed laddu was done. The Appearance, Odour, Acidity, Moisture, Ash, Acid insoluble Ash, other extraneous matter were the chemical parameters analyzed. Heavy metals like Lead, Mercury, Cadmium, Nickel, and Arsenic were also analyzed.

Microbiological analysis of the laddu

Microbiological analysis of the laddu was done on day one and on day 15 which included Total Plate Count, E-Coli, Coliform, Salmonella, Yeast and Mould.

Statistical analysis

The sensory data obtained was subjected to analysis of variance (ANOVA) using SPSS version 21.0. The data was expressed as mean $\pm$ standard deviation and the difference between samples was considered significant if its level of significance $p < 0.05$.

RESULTS AND DISCUSSION

The laddus prepared with various composition along with standard were subjected to sensory evaluation. Table 2 shows the comparison of the scores of three different variations with regard to organoleptic properties.

Duncan Multiple Range Test (DMRT) was conducted to find which two variations differ significantly. It is seen from the above table that except texture all the variations differ significantly with respect to all the attributes as well as overall acceptability. Sensory evaluation confirms incorporation of cauliflower leaves powder had significant effect on sensory properties of the laddu. The mean score of V1 (7.0) was found to be more than V2 (4.0) and V3(3.2) for overall acceptability.

Table 2. ANOVA for significant difference among the prepared food supplements with respect to organoleptic properties

Organoleptic properties of the supplement	Group				F value	P value
	Standard	V1	V2	V3		
Appearance	7.933 ^d (.254)	6.767 ^c (.504)	6.000 ^b (.371)	4.033 ^a (.414)	513.643	<0.001**
Colour	7.667 ^d (.711)	6.933 ^c (.365)	5.767 ^b (.504)	5.033 ^a (.414)	155.878	<0.001**
Flavour	7.767 ^d (.568)	7.067 ^c (.365)	5.133 ^b (.346)	5.867 ^a (.507)	201.000	<0.001**
Texture	7.833 ^d (.379)	7.867 ^d (.346)	4.967 ^b (.414)	6.800 ^a (.484)	331.789	<0.001**
Taste	7.900 ^d (.305)	6.967 ^c (.490)	4.100 ^b (.403)	2.167 ^a (.379)	1301.523	<0.001**
Overall Acceptability	7.767 ^d (.504)	7.000 ^c (.455)	4.033 ^b (.414)	3.167 ^a (.531)	655.862	<0.001**

1. The value within bracket refers to SD
2. ** denotes significant at 1% level.
3. * denotes significant at 5% level.
4. Different alphabet among products denotes significant difference at 5% level using Duncan Multiple Range Test (DMRT)

Incorporation of cauliflower leaves powder was found to reduce the sensory attributes of the laddu with the increase in the level of incorporation, which is similar to the study reported by Roshini Singh & Nidhi Verma (2022). Similarly, inclusion of Garden cress seed powder at 10% level was found to be acceptable which is in consistent with study by Tanu Jain *et al.*, (2016). The quality of taste received the lowest score of 2.6 for 15% of cauliflower, garden cress seed and amla incorporated product. Duncan's multiple range tests applied to check for differences in between the samples, revealed that they were not similar in any of the sensory attributes. However, the 10% cauliflower garden cress, and amla incorporated product was found to be similar to control in terms of texture, flavour and overall quality although significant

difference was seen in appearance and colour. Laddu prepared with nutrimix V1 was chosen as food supplement based on the average perception and overall acceptability.

Nutritional analysis of the laddu

The nutrient composition of the laddu prepared with the nutrimix V1 was analyzed by appropriate methods and is given in table 3.

The nutrient composition of Nutri laddu shows that 100g of laddu provides 412.58 kcal, 47.78g of carbohydrates, 12.93 g of protein, 18.36 g of fat, 2.54 g of crude fibre. The mineral composition level indicated 655.93 mg of calcium, 7.32 mg of iron, and the vitamins A and C were 8.42IU and 19.25 mg respectively. In a study by Padma *et al.*, (2019) laddu made of health mix provided protein 13.90g, fat 5.46g, carbohydrates 71.54g, energy 348.16

Table 3. Nutritional composition of the Laddu(V1)

Nutrients	Formulated product-Laddu (V1) per 100g
Calories (kcal)	412.58
Carbohydrate(g)	47.78
Protein(g)	12.93
Fat(g)	18.36
Crude Fiber(g)	2.54
Calcium(mg)	655.93
Iron(mg)	7.32
Vitamin A (IU)	8.42
Vitamin C(mg)	19.25

kcal, iron 9.10mg, calcium 210mg per 100 gm. The nutriladdu developed had nearly the same nutritional composition as that of the millet laddu developed by Subbaiyan *et al.*, (2024) which was found to have 11.13 g of protein, 64.47 g of carbohydrate, and 15.13 g of fat per

100 g of the product. The protein, fat and iron content of the nutriladdu is higher than that of the pearl millet laddu formulated by Rubavathi *et al.*, (2022), which showed that the protein 9.9 ± 2.8 g, fat 4.2 ± 0.5 g carbohydrate 69 g per 100g. Laddu produced solely with ragi by Shazia *et al.*, (2023) had a total protein value of only 3.18g/100, but nutriladdu formulated with ingredients from various food groups had a protein content of 12.93g/100g, suggesting that it not only offers diversity but also enhances the nutritional composition overall.

Chemical analysis of the laddu

Physicochemical properties and heavy metal analysis of the laddu prepared with the nutrimix V1 are provided in Table 4 and it depicts that the results meet the acceptance criteria.

The results for physicochemical analysis revealed that appearance was good and odour was agreeable and there was no extraneous matter present thus making the laddu acceptable for consumption. Other attributes

Table 4. Physicochemical and Heavy Metal analysis of laddu (V1)

Physicochemical analysis		
Parameter	Specification	Result
Appearance	Good	Good
Odour	Agreeable	Agreeable
Acidity	Max 0.2%	0.08%
Moisture	Max 7.0%	4.0%
Ash	Max 5.0%	1.5%
Acid insoluble ash	Max 0.1%	0.02%
Other extraneous matter	To be absent	Absent
Heavy metals analysis		
Lead	Max 5.0 mg/Kg	0.5 mg/kg
Mercury	Max 0.25 mg/Kg	<0.01mg/kg
Cadmium	Max 1.0 mg/Kg	<0.01mg/kg
Nickel	Max 0.5 mg/Kg	<0.01mg/kg
Arsenic	Max 0.5 mg/Kg	<0.01mg/kg

Table 5. Microbiological analysis of the Laddu (V1)

Parameter	Specification	Result	
		First day	After 15 days
Total plate count	Max10 x 10 ³ CFU/g	200 x 10 ¹ CFU/g	270 x 10 ¹ CFU/g
E.Coli	Absent	Absent	Absent
Coliform	<10CFU/g	0 CFU/g	0 CFU/g
Salmonella	Absent	Absent	Absent
Yeast and Mould	<10CFU/g	0 CFU/g	0 CFU/g

like acidity, moisture and ash were within the permissible limit. The heavy metal analysis to measure the level of toxic metals like lead, mercury, cadmium, nickel, arsenic present in laddu by Inductively Coupled Plasma Spectrometry (ICP-MS) proved that the detected concentrations were within the regulatory standards recommended by FSSAI (Food Safety and Standards Authority of India).

Microbiological analysis

The storage stability results of the microbiological analysis of Nutriladdu prepared with the nutrimix V1 are given in table 5 and are in compliance to specification thus making it acceptable for consumption.

Microbial testing on first day and after fortnight to identify food borne pathogens and storage organisms to ensure food safety. The total plate count in the laddu was 200CFU/g on the first day and 270 CFU/g after 15 days. There was no growth observed for Coliform, Yeast, and Mould, and E. coli and Salmonella were not present at any point during the storage period. Thus, the Microbial analysis proved that the Nutri laddu was free of biological hazards and safe for consumption.

CONCLUSION

The result signifies that incorporating energy rich ingredients such as jaggery, ghee along with inexpensive and indigenous iron rich ingredients such as cauliflower leaves, garden cress seeds as functional ingredients

from different dietary groups in the-nutritious snack provided 412.58 kcal, 12.93 g of protein, 655.93 mg of calcium, 7.32 mg of iron per 100gm of laddu. The Nutriladdu prepared with 10 % incorporation of cauliflower leaves, garden cress seeds and amla powder was found to have better overall acceptability. The results of physicochemical analysis confirm that the appearance was good, odour was agreeable, heavy metals and other attributes were within the permissible limits, and no extraneous matter was present. Thus, the nutritional composition, sensory attributes and the storage stability of the laddu makes it suitable for consumption as well as more comprehensive understanding of utilizing iron rich food sources in traditional food preparation, potentially paving the way for food-based approach for preventing iron deficiency anaemia. Further the study can be extended to assess the phytochemicals, bio accessibility and bioavailability of nutrients present in the developed Nutriladdu.

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